Gesture, Instrument and Musical Creation : the System ANIMA/CORDIS

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The purpose of our research is to build a musical creation tool turning the computer capabilities to the best account.
We adopt an overall and complete approach to this problem. We present here some theoretical elements and technological consequences of this approach.

THE FIRST FUNCTION OF COMPUTER IN OUR MUSICAL CREATION TOOL

Musical practice begins with instrumental experience. The instrument and the instrumental experience are the first basis of the learning of music. The mastery of sounds language, even in its very abstract level, is partially founded on an instrumental knowledge of sounds. It is precisely that instrumental knowledge which is lacking with the greatest part of synthesized sounds universe.

Thus, the first function we assign to the computer as musical creation tool is to give a representation of the instrumental universe that we can experiment in the same way we should experiment the true instrumental universe.
This representation implies necessarily a reduction of the real instrumental universe, but, at the same time, it introduces two new fundamental facts :
- a broadening of that instrumental field towards unknown and otherwise impossible spaces,
- a control of the represented field unreachable with real instruments.

THE INSTRUMENTAL EXPERIMENT AND THE INSTRUMENT

What we mean by instrumental experiment is not only the "how to play traditional instrument".
It means more fundamentally the sum of all the sensory-motor experiments done, since our birth, over various environmental objects producing sound.
In this experiment the acoustical perception has a priviledge role, but it is inseparable of :
- a motor action that we call gestual action,
- other perceptions. More precisely the perception in instrumental experiment is a multisensory and overall phenomenon. Three channels are concerned : gestual, acoustical and visual.

The gestual channel has a very special place because of its bilaterality : It is simultaneously an emitter (of action) and a receiver (of perception).
We will call "gestual perception" the whole tactile or dynamical kinestesic perception which accompany an action on a material object.

The visual channel has a complementary role over the two others : It takes place in a specific manner, in overall perception, as well as in the accomplishment of the instrumental gesture : giving information on the various objects and their relations it allows overall control on instrumental playing.

THE INSTRUMENT AND THE INSTRUMENTAL GESTURE

The instrument permits the gesture "to reach the ear". It's physical function consists in transforming a slow mechanical phenomenon in an acoustical phenomenon.
Generally, instruments are made of two mechanical macro components:
- the vibrating structure whose mechanical movments are essentially acoustical,
- the excitor whose mechanical movment are slow. It transforms the instrumental gesture in an excitation for the vibrating structure.
The specificity of the link between the excitor and the vibrating structure defines the way of transmission of the mechanical energy from the gesture to vibrating structure.

Generally, the instrumental gesture is of two natures : we shall call them the excitation gesture and the modification gesture.
The excitation gesture is the source of the sound energy. The role of the instrument is here to transform the mechanical energy produced by the gesture in an acoustical energy.
When a violonist plays, the left hand which holds the bow makes the excitation gesture.
This gesture is applied on the excitor which is then a mechanical load for the instrumentist. Two corollaries of this fact are :
- the carrying out of the excitation gesture is influenced by the nature of the excitor,
- the excitation gesture is inseparable from the gestual perception.
The modification gesture modifies the mechanical characteristics of the instrument and has as effect a modification of sound. When the violonist plays, the left hand makes the modification gesture : it modifies the string's length. In this case, the energy contribution is rather small and it doesn't take part in the energy of the sound. As a corollary, the gestual perception is not a necessary fact in the modification gesture.

THE FUNCTIONS OT THE MUSICAL CREATION TOOL AND THE CORRESPONDING DEVICES

1. The central function of the Musical Creation Tool is the concrete representation of the instrumental field. It implies the creation of three kinds of devices :
- a set of transducers
- a system of simulation algorithms of instruments
- a recording device for the instrumental gesture

The function of the transducers is to relate the events belonging to the sensory field and those belonging to the computer technology field, i.e. digital signals. There are three kinds of transducers, one for each of the three perception channels.

We must pay a particular attention to the specificity of gestual transducers, and especially gestual transducers with mechanical feedback (T.G.R.: in french: "Transducteurs Gestuels Rêtroactifs") which support the bilaterality of gestual channel, especially for the excitation gesture.

The function of the system of algorithms is to calculate the digital signals which represent the movments of an object in a physically consistant way.

Conservation of instruments being made overwhere, the recording of gestures assures an objective recording of the whole instrumental experiment.

2. Above the instrumental experiment :
Above the effective simulation of instruments, a step of instrumental design, image of traditional instrument making, is necessary. This task will be supported by an appropriate system, "the pre-structural system". It depends on the set of algorithms for simulation but it must be also an explicite, consistant and complete and interactive language.
This step requires the design of a specific man-machine interface supported by convenient graphical symbolisms of the instrumental structures.

The system must assure the recording of the instruments thus built.

3. Below the instrumental experiment :
The basic interest of instrumental universe computer representation is that any object (instrument) and any event (instrumental experimement) can be :
- memorized in an objective and absolutly precise way
- represented in a multidimensional and non-temporal form.
These two functions give way from the instrumental experiment to the compositional activity.
Then, the third step is composition, which is a sound structuration. Following the two previous steps, the compositionnal activity may applies on the previous objects : the recorded gestures and instruments, supported by a graphic representation of instrumental gesture.
It is possible to developpe material composition systems that all will be treatment, transformation, combination and representation systems of instrumental gestures and structures.

The three steps we discuss above take place more in a logical order than in a chronological one, and a given creation experience may begin from any level if a memorised "context" exists.

CONSTRUCTED AND EXPERIMENTED TECHNOLOGICAL ELEMENTS

To build this tool, we have to study and realised several special mechanical devices, hardware and software systems :
- a gestual transducer with mechanical feedback,
- the algorithm system and the CORDIS and ANIMA languages,
- the real-time special-purpose CORDIS processor.

1. We have built two prototypes of gestual transducers. The second has external dimensions similar to a piano key. It contains a force sensor with strain gauges, a displacement sensor with inductive effect (with 10 micrometer of sensibility), and a torque motor. It is connected to the simulation system by means of conditioning devices and an appropriate interface.

2. To implement a consistant simulation algorithms system we need first a mechanical modelisation of the instrumental universe. The ANIMA/CORDIS simulation system is founded on four basic mechanical elements corresponding to four kinds of digital algorithms. These

algorithms give the simulation of linear mechanical models which are : a ponctual mass, a stiffness element, a friction element, and a system of non-linear elements.
ANIMA/CORDIS is an entirely modular system whose elements may be combined, following only a consistant mechanical logic.
This system contains also primary modules corresponding to the most employed arrangements of the basic elements.
The ANIMA/CORDIS language allows the description of any mechanical structure (excitor or vibrating structure) by only these basic elements.

3. The real time CORDIS processor, connected to the host-computer gives the real time simulation of vibrating mechanical structures. It uses the three primary modules of the ANIMA/CORDIS system. It allows the real- time simulation, at a rate of 25,6 KHz sampling frequency, of vibrating structures composed by up to twelve material distinct points.
Its internal architecture is somehow similar of an array processor, using the technics of parallel and pipe-line architecture, and the specialisation of the memories. The computation is carried on a 32 bits fixed point format.